BRAZILIAN PROGRAM FOR REMOTE SENSING OF EARTH RESOURCES

PROJECT SERE

by

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LAFE-152

May 1971

INTERNATIONAL WORKSHOP ON EARTH RESOURCES SURVEY SYSTEMS

Ann Arbor - Michigan

May 3-14, 1971

PR - Conselho Nacional de Pesquisas
Comissão Nacional de Atividades Espaciais
São José dos Campos - SP - Brasil

PRESIDÊNCIA DA REPÚBLICA
CONSELHO NACIONAL DE PESQUISAS
COMISSÃO NACIONAL DE ATIVIDADES ESPACIAIS
São José dos Campos - Estado de São Paulo - Brasil

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This report contains elements of CNAE's research program and its publication has been approved by

Fernando de Mendonça
Scientific Director

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Introductory Remarks

This short report contains a description of the Remote Sensing of Earth Resources Program as it is being implemented in Brasil. We tried to present the situation as succintly as possible. In what follows the emphasis will be accordingly placed on the main features of the program, concerning its short past and the present situation, without, however, leaving out of account possible future repercutions of the trends that are becoming apparent.

Due to its nature and the way the program is being developed in Brazil,at present, we could not avoid an almost purely descriptive presentation, and only in very few cases operational aspects could be supplemented by some more specific data. Anyway, we hope this information will be of some value and will reflect as faithful as possible, the experience of our own country with its own particular features and problems.

Obviously, the concept of our program, its contents, aims and methods, and the structure which enable it to be formulated and carried into effect, vary considerably from other countries, since it is determined by the country social and economic system, its level of development, geographical extension and situation, scientific and technological potential, targets for future development, and national tradition in various spheres (such, for instance, as higher education, scientific research, industry, etc.).

Structure

Among the main reasons advanced to explain the need for and complexity of, a Remote Sensing of Earth Resources Program in Brazil, mention should be made of the following:

The increasingly dependence growing up between the goal of national economical and social development and the exploration and exploitation of vast unknown regions of a country of continental size; the magnitude of the human and financial resources to be devoted to the program, making government action and support a basic responsability; the inevitable limitations of human and financial resources actually devoted, which in practice oblige the coordinating authorities of the program to determine its options, and to establish priorities; the steadily increasing role and extent of international cooperation in the sphere of science and technology; and the problems arising from a rapid evoluting technology and the complex and varied nature of the objectives in view.

It seems important to start indicating the purposes,position and relationships of the agency, designated by the Brazilian Government to implement and coordinate the Earth Resources Remote Sensing, in the Brazilian scientific and technological research community.

This agency is a space science and technology oriented Brazilian Government institution, linked to the National Research Council, the governmental body that coordinates Research activities in Brazil. This council reports directly to the Presidency of the Republic.

The plans established for CNAE, as a whole, covering the period of 1969 to 1973 foresee a growth judged compatible to the country's financial possibilities, and are based on a realistic appraisal of the industrial development and of the qualifications of Brazilian scientists and technicians.

Recently the Brazilian Government promulgated a law, creating, at the National Security Council level, a Space Committee, a policy and program-budget planning advisory body.

The space institution, known as CNAE (Comissão Nacional

de Atividades Espaciais) and which will soon be renamed INPE (Instituto de Pesquisas Espaciais), has its headquarters at São José dos Campos, State of São Paulo, it was created by federal law, in August 1961. Its responsibilities are related to a clearly defined section of research and development: it is the only civilian institution exclusively dedicated to space science and technology in Brazil, and it is in charge of coordinating civilian space activities of other groups.

Since its creation, our agency has maintained a close cooperation with NASA. This cooperation has proved to be particularly beneficial in helping to pull up the country to a position within the group of nations which most closely succeed the scientifically advanced nations.

Early in 1966, NASA suggested the participation of our agency in a remote sensing cooperative project for the aerial survey of certain selected areas which were to be used as "lunar analogues". This initial idea was soon abandoned, but from it evolved a cooperative program, associating Brazilian and United States groups, with the purpose of developing techniques and systems for acquiring, interpreting and utilizing, earth resources data collected by aircraft in order to determine the potential utility of spacecraft applications of the techniques.

The first step of this cooperative program was accomplished in 1968, with the completion of a six month training period of twelve Brazilian scientists in the U.S.A. In the next year, after the development of five test sites in Brazil in cooperation with local user agencies, took place the NASA aircraft overflights of these sites. This happened in July 1969. The study of the results of that aircraft mission had special significance in deciding the desirable configuration of our own aircraft-sensor system.

In October, last year, a meeting, with the presence of NASA representatives, took place at our institution main center for the formal presentation of the final reports of the third phase of the NASA-CNAE cooperative program.

The Brazilian aircraft operational flights which constitute the fourth phase of the program, will start soon with a Brazilian built aircraft. This aircraft is in process of being instrumented by its builders, at their factory, located in the vicinity of our main laboratories.

From experience obtained during the preparatory phase of the NASA aircraft mission (mainly test site development), the overflight mission itself and in the development of the data analysis and interpretation phase, became clear the need of a fundamental change in the approach of the whole program.

One of the facts which became apparent was the extremely different paces of the work being done at different user agencies, as expressed by differences in internal support encountered by theirs principal investigators (the primary cause of these differences could not be explained by lack of financial resources). The actually provided support varied from a full unrestricted one to almost none, as observed.

Another aspect of the above mentioned difficulty, was the manner of presentation of the project to the prospective users. As everybody knows, any initial proposal concerning remote sensing is so appealing that the expected results are readily super-estimated. Thus, in certain groups, fast obtained motivation, faded out fast with the first minor difficulty. By contrast, the early successes of other discipline groups, created an enthusiastic attitude leading to decisions to start using the already available equipment for extensive aerial surveying projects. A more realist position was adopted by investigators with a clearer understanding of a particular sensor capability and the significance of the sensed data and such was the case of remotely measured sea surface temperatures for the oceanographers. Since the beginning of our program, and for a long period of time, an one-way flow of simple support was established: from the data collecting and processing activity to the data interpreter. The task of the supporting activity ended at the moment the data was delivered to the investigators as a carefully collected and processed agregate of data, in the manner liberally

specified (as test site location and extension, sensors selected data quantities, etc.) by the investigator himself. To correct this undesirable situation, we are trying to regulate the process basing our present efforts on a truly specific objective motivated type of operation of the system.

Thus, our in-house discipline interface groups, formed by relatively numerous and well qualified specialists in natural and cultural earth resources, working in close relationship with our instrumentation, flights operations, data processing and bank groups, try to maintain adequate channels for an exchange of ideas on progress and program development between the Brazilian user agencies, our own organization and foreign counterparts. It is also their duty to bring back to CNAE the problems generated at the users areas, thus establishing a close-loop system. By so doing, we expect to have a complete system animated and stimulated by resources minded and instrument acquainted in-house people and not by the instrumentation experts providing subsystems of data collection. To keep the system working smoothly we have an internal group specialized in system analysis; this group is in charge of the project planning and control functions.

To assure adaptability and flexibility to a system dealing with frequently changing "specific objectives" or sub-projects a matrix type of organization charts is being used in our Remote Sensing Project. In this type of organization, a well established set of basic functions - the functional groups - work only in a support relationship to the different sub-projects being developed. In other words, the functional groups exist to provide functional personnel to active sub-projects and give support assistance to their scientists. The on-going sub-projects, in a matrix organizational chart, may be graphically shown by the respective group of scientists, horizontally aligned by specific sub-project with these groups vertically located under the functional groups from which they originated. Additional sub-projects may be easily added, and as completed or phased out sub-projects are excluded from the organization, the personnel return to the original functional group. See figure at the end of this paper.

Human Resources

For the development of such program, our institution must rely on a significant group of scientists and technicians, in quantity as well as in quality. Due to the lack of proper educational centers in Brazil teaching subjects directly related to the field of remote sensing, it was necessary for CNAE to develop its own courses, organized with the help of the few specialists trained in the U.S.A.

At the moment we have the following groups of specialists working at the Remote Sensing Project:

Agronomists	13	Discipline Group = 25
Geologists	8	
Oceanographers	3	
Geographer	1	
Electrical Engineers.....	5	Data Collecting Group = 13
Electronic "	2	
Physicists.....	2	
Pilots.....	2	
Aerophotogrammetrists.....	2	
System Analysts	3	
Librarian	1	
Secretaries.....	2	44 Total

The project will be fully operational only when the remote sensing aircraft BANDEIRANTE - PP-7CN is put to routine use, probably by the end of May this year. Meanwhile, the discipline specialists are still working with the data collected during the NASA aircraft overflights in Brazil, in close contact with the user agencies specialists.

The supporting groups are working in interpretation techniques development such as:

1. To develop Analysis or Digital Information Extraction Techniques.

2. To develop and Evaluate Decision-Oriented Resources and Environmental Models, for example:

   Numerical Prediction Models (e.g. River Basin Models)
   Conceptual System Models (e.g. Epidemiological Models)
   Management Models (e.g. Relevant Enterprise Models)
   Multistage Sampling Models (e.g. Statistical Inventoring)
   Temporal Models (e.g. Crop Calendars)
   Statistical Classification Models

and in sensor Technology:

   Numerical parameters: sensitivity, resolution, Signal-to-noise, Error, Degradation, etc.

In cooperation with the Brazilian Institute of Coffee and utilizing data collected by contracted private aircrafts, some work is being done in coffee plantations areas hit by frost, infested by nema - toides and infected by coffee leaf rust. In this work only photographic sensors are employed. Color Ektachrome and False Color IR Ektachrome films were used.

In addition CNAE mantains agreements with the following Brazilian Government agencies which participate in the program with their own investigators:

- The Ministry of Mining and Energy, through its Departments of Mineral Production and of Water and Electrical Energy.
- The Ministry of Agriculture, through the Office of Research and Experimentation
- The Ministry of Trade and Industry, through its Brazilian Institute of Coffee
- The Ministry of the Navy, through its Hydrographic Office
- The São Paulo State Secretary for Agriculture through the Agronomic Research Institute of Campinas and the Institute of Agronomical Economy
- The University of São Paulo by its Oceanographic Institute and the Institute of Geophysics.

This cooperative system tends to grow.

We are trying to implement and operate the best system compatible with the available talent. All efforts are being made to benefit from the potencial of young university graduates from the higher level Brazilian colleges.

But young scientists and engineers usually change jobs more frequently than the older ones; thus some start working in relevant branch of industry and move to research, while many others move in the opposite direction, specially in a developing country. CNAE is a young organization, so it is its staff. We, definitively need experienced people for the key positions. But experienced scientists and engineers are reluctant to move to another job, if this means relinquishing a post in which they enjoy stable career prospects which span their whole probable working life.

Thus it has become necessary for CNAE to train its own staff and to prepare its own leaders, consequently our center, at São José dos Campos, became a combination of a post-graduate school and research laboratories. This is an unvoidable constrain to our human resources.

Material Resources

Budgetary Resources

The annual budget of our institution is supplied through the National Research Council (CNPq). For the current fiscal year it amounts to about US$ 7 million, when we add resources from all sources.

The National Development Bank (BNDE) through the Technological and Scientifical Fund (FUNTEC) cooperated for the development of the Remote Sensing Project providing the equipment which is already in use or it is being installed on board of the aircraft. The aircraft itself was bought with resources from our own budget.

Material Resources

CNAE BANDEIRANTE AIRCRAFT PP-ZCN

The CNAE PP-ZCN is a two-engine, low wing aircraft modified to carry passive sensor equipment. It has a maximum take-off weight of 11220 lb and is powered by two turboprop engines. It requires a crew of two pilots, one flight director and two sensor operators. It was designed and built by the EMBRAER S.A. located at São José dos Campos.

Aircraft Performance

Altitude: Sea level to 28000 ft
Airspeeds: 226 kt (cruising), 275 kt (max)
Payload - 4000 lb
Range (at 10000 ft) 1000 nautical miles
Operates from small airfields

This aircraft is equipped with the following instruments:

- Wild RC-10 Metric Camera
- Hasselblad 500 EL/70 Four Camera Cluster
- Bendix LN-3 Thermal Mapper (2 channels, one thermal)
- Barnes PRT-5 Precision Radiation Thermometer
- Ampex AR-1600 Mag. Tape Recorder
- Bendix DRA-12 Doppler Radar
- Bendix AN/APN 184 Radar Altimeter
- Bendix M-4C Automatic Pilot

Photographic Laboratory

The CNAE photographic lab has a basic capacity for:

- Automatic Black and White Film Processing up to 9 1/2 inches wide
- Semi-automatic Color Film Processing up to 9 1/2 inches wide
- LogEtronic Printing up to 9 1/2 inches wide
- Color and Black and White Enlargements.

Analog/Digital Data Conversion

- HP 2116 B Computer (16K word Memory)
- Teleprinter
- Paper Punch Reader
- Tape Punch
- Magnetic Tape Units (2)
- HP 2311 C, ADC Subsystem with Walthom 56 IDA
- HP 2791 A, Pacer for high speed data aquisition

Future Developments

Three proposals were forwarded to the NASA Office of International Affairs for investigations using data from the first earth resources satellite, this participation being part of the fourth or D Phase of the Plan of Cooperation between Brazil and the U.S.A. for applications of Remote Sensing.

Our own in-house proposals covers the following disciplines:

- AGRICULTURE - FORESTRY - GRASSLANDS, to study the viability of scientific uses and economic substitution of the conventional methods of surveying natural and cultural resources by satellite data.
- GEOLOGY, to study the application of remote sensing for geological and mineral resources survey.
- OCEANOGRAPHY, to develop a method of bathymetric studies from satellite imagery.

In addition, two other proposals were prepared by two cooperating agencies namely the Ministry of Mines and Energy and the Brazilian Institute of Coffee of the Ministry of Trade and Industry.

The first being "A Proposal for the Application of ERTS-A

Data to Resources Analysis of the Amazon Basin" and the second "Experimentation to verify the viability of orbital images interpretation in order to know the physical aspects of the Brazilian Coffee".

With these two proposals, the user agencies are seeking a program of research which will fit in and, perhaps, supplement two present on-going earth resources aircraft projects. They are the Ministry of Mines and Energy RADAM Project and the Brazilian Institute of Coffee, Photointerpretation Service Project.

The first is a multidisciplinary project based in a complete aircraft coverage of part of the Amazon Region (1500000 km^2) gathering data with synthetic aperture SLAR in conjuction with limited amounts of multiband aerial photography taken from high and low altitudes, and ground truth, to map mineral, vegetation, soil and water resources. The flights are scheduled to start June 1st and shall be finished after a period of four months.

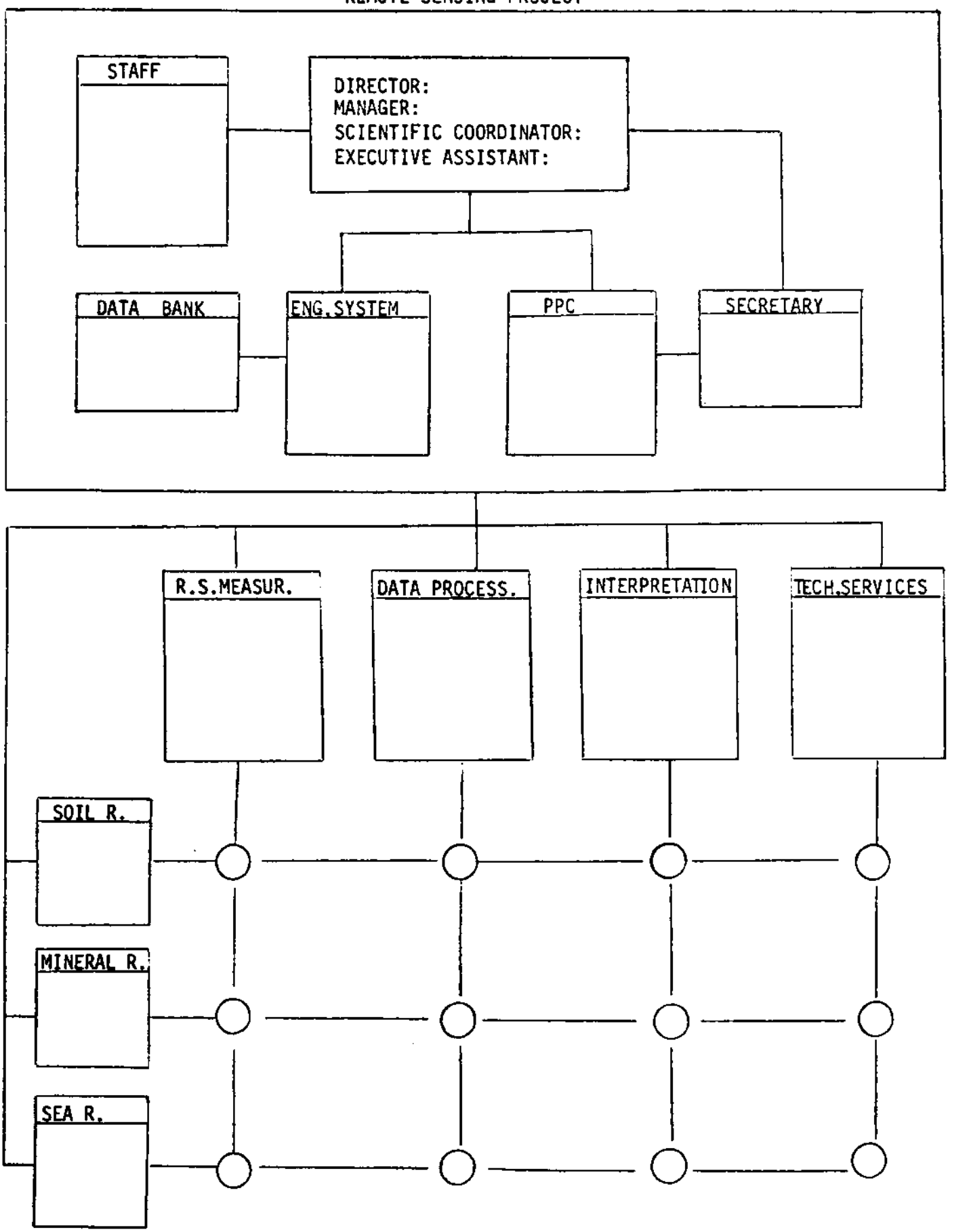
The second project is an agriculture project dealing with coffee resources management (inventory, yield prediction, etc.). In both cases there will be correlative data in such conditions that the resultant data from the proposed satellite experiments, shall be analysed with in short periods of time.

Our Institution will act not only as the coordinating agency, but will have its own discipline investigators working within the users teams and will provide support in the following activities:

1) Aircraft underflight requirements,
2) Photographic processing laboratory,
3) Data analysis and information extration, such as densitometry, multispectral projections, computer processing.
4) Data receiving, storing, retrieval and distribution center (Data Bank).

Our in-house proposal, besides its scientific specific objectives, aims to keep up-dating our own discipline investigators competence to solve problems arising from a rapid evoluting technology.

MATRIX ORGANIZATION CHART
REMOTE SENSING PROJECT



R = RESOURCES PPC=PROGRAM PLANING CONTROL R.S.MEASUR=REMOTE SENSING MEASUREMENTS